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ORIGINAL ARTICLE

Burden of Maternal Malnutrition on Endocrine Balance, Antenatal Complications, Neonatal Respiratory Morbidity

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ABSTRACT

Maternal malnutrition remains a pervasive challenge, particularly in low- and middle-income countries, with established implications for maternal endocrine regulation, pregnancy outcomes, and neonatal health. This cross-sectional observational study evaluated the impact of maternal malnutrition on endocrine balance, antenatal complications, and neonatal respiratory morbidity among pregnant women attending antenatal services in Pakistan. Maternal nutritional status was assessed using body mass index (BMI), serum albumin, and micronutrient profiles in the second trimester, while endocrine parameters included fasting insulin, thyroid hormones, and cortisol levels. Antenatal complications such as gestational hypertension, preterm labor, and gestational diabetes mellitus were documented. Neonatal respiratory morbidity was assessed through standard clinical criteria and the need for respiratory support during the first 72 hours of life. Among 300 enrolled participants, 128 (42.7%) were categorized as malnourished. Malnourished mothers exhibited significantly altered endocrine parameters, with higher cortisol and lower thyroid hormone levels ($p < 0.001$), and a higher incidence of antenatal complications ($p = 0.002$). Neonates born to malnourished mothers demonstrated increased respiratory morbidity ($p < 0.001$), longer neonatal intensive care stays, and elevated requirement for ventilatory support. Multivariate analysis identified maternal malnutrition as an independent predictor of neonatal respiratory morbidity after adjusting for confounders. These findings emphasize the multifaceted burden of maternal malnutrition and the need for integrated nutritional interventions to improve both maternal endocrine health and neonatal respiratory outcomes.

Keywords: *Maternal malnutrition, Endocrine balance, Antenatal complications, Neonatal respiratory morbidity*

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INTRODUCTION

Maternal nutrition is a cornerstone of healthy pregnancy, influencing maternal physiology and the development of the fetus. Nutritional status before and during pregnancy exerts profound effects on endocrine function, immunological adaptation, and metabolic homeostasis. Maternal malnutrition, defined as undernutrition in the context of insufficient macro- and micronutrient intake, remains a prevalent public health problem in many resource-constrained settings. Globally, undernutrition among women of reproductive age contributes significantly to adverse pregnancy outcomes, reflecting the interplay between nutritional deficits and physiological adaptations necessary to support gestation. This burden is compounded by socioeconomic disparities, food insecurity, and limited access to antenatal care services, which together exacerbate the risk of complications during pregnancy and childbirth [1-4].

Pregnancy induces complex endocrine changes to support fetal growth, maternal metabolic demands, and parturition. Hormones such as thyroid hormones, insulin, and glucocorticoids are intricately involved in regulating energy homeostasis, placental function, and fetal organ maturation. Adequate nutritional substrates are essential for maintaining this hormonal balance. Malnutrition can disrupt thyroid hormone synthesis, alter glucose metabolism, and activate the hypothalamic-pituitary-adrenal axis, leading to elevated cortisol levels. These endocrine perturbations have implications for both maternal health and fetal development, potentially increasing vulnerability to antenatal complications such as gestational hypertension, preterm labor, and gestational diabetes mellitus. Despite recognition of these associations, comprehensive population-based data linking maternal malnutrition, endocrine imbalance, and specific pregnancy outcomes remain limited, particularly within South Asian contexts [5-7].

Antenatal complications contribute substantially to maternal and perinatal morbidity and mortality. Gestational hypertension and preeclampsia, for example, are leading causes of adverse outcomes and are influenced by maternal nutritional status and metabolic function. Undernourished women may experience placental insufficiency and compromised vascular adaptation, increasing the risk of hypertensive disorders. Similarly, inadequate maternal nutrition is implicated in glucose intolerance during pregnancy, affecting insulin sensitivity and increasing the risk of gestational diabetes. These conditions, in turn, can influence fetal growth trajectories and predispose neonates to a range of complications [8-12].

Neonatal respiratory morbidity is among the most common causes of early-life morbidity and mortality. It encompasses conditions such as respiratory distress syndrome, transient tachypnea of the newborn, and bronchopulmonary dysplasia. The etiology of these conditions is multifactorial, with prematurity, intrauterine growth restriction, and maternal health status recognized as key determinants. Maternal malnutrition has been associated with fetal lung immaturity, surfactant deficiency, and weakened neonatal respiratory drive. However, the extent to which maternal nutritional status directly influences neonatal respiratory morbidity, independent of gestational age and birth weight, requires further elucidation.

Investigations into the relationship between maternal nutrition and endocrine function have highlighted the importance of micronutrients such as iodine, iron, and vitamins in supporting thyroid function and metabolic regulation. Deficiencies in these nutrients can impair hormone synthesis and secretion, leading to a cascade of physiological disruptions. Similarly, protein-energy malnutrition affects insulin production and sensitivity, altering glucose homeostasis and potentially contributing to gestational diabetes. Elevated maternal cortisol, often seen in states of chronic nutritional stress, may influence fetal hypothalamic-pituitary-adrenal axis development, with implications for neonatal adaptation and respiratory function.

The intersection of maternal malnutrition, endocrine imbalance, and perinatal outcomes represents a complex clinical and public health challenge. While individual associations have been described, integrated studies examining these domains collectively are scarce. Such investigations are critical for informing targeted interventions aimed at mitigating the burden of maternal and neonatal morbidity attributable to nutritional deficits. In Pakistan, where maternal undernutrition remains common and healthcare resources are constrained, understanding these relationships is essential for optimizing antenatal care and improving neonatal health outcomes.

The present study was undertaken to investigate the burden of maternal malnutrition on endocrine balance, the incidence of antenatal complications, and the prevalence of neonatal respiratory morbidity in a cohort of pregnant women in Pakistan. By incorporating standardized nutritional assessments, biochemical evaluations of endocrine function, and clinically defined maternal and neonatal outcomes, this research aims to generate evidence to guide policy and clinical practice in maternal and child health.

The objective of this study was to assess the association between maternal nutritional status and neonatal respiratory morbidity among pregnant women in a tertiary care setting.

MATERIAL AND METHODS

Study Design and Setting

This cross-sectional observational study was conducted at CMH Lahore Medical College, a tertiary care hospital in Pakistan, over a seven-month period.

Ethical Considerations

The study protocol was approved by the Institutional Human Ethical Committee of CMH Lahore Medical College. Verbal informed consent was obtained from all participants after explaining the study objectives and procedures.

Sample Size and Participants

Sample size was calculated using Epi Info software (version 7), assuming a 95% confidence interval, 80% power, an expected prevalence of neonatal respiratory morbidity among malnourished mothers of 30%, and a 10% margin of error. A minimum required sample of 280 participants was determined, and 300 pregnant women were enrolled to account for potential dropouts.

Inclusion Criteria:

- Women aged 18–40 years
- Singleton pregnancies in the second trimester (14–28 weeks)
- Provision of verbal informed consent

Exclusion Criteria:

- Multiple pregnancies
- Preexisting endocrine disorders
- Chronic systemic illness
- Recent corticosteroid therapy

Maternal Assessment

Nutritional status was determined through measurement of body mass index (BMI), serum albumin, and micronutrient levels (iron, folate, vitamin D).

Endocrine parameters included fasting insulin, thyroid-stimulating hormone (TSH), free thyroxine (FT4), and serum cortisol.

Antenatal complications documented included gestational hypertension, preterm labor, and gestational diabetes, determined through clinical evaluation and standard laboratory criteria.

Neonatal Assessment

Neonatal respiratory morbidity was defined as the presence of clinical signs requiring supplemental oxygen or mechanical support within the first 72 hours post-delivery.

Statistical Analysis

Data were analyzed using statistical software. Group comparisons were conducted using independent t-tests for continuous variables and chi-square tests for categorical variables. Multivariate logistic regression analysis was employed to identify independent predictors of neonatal respiratory morbidity. A p-value < 0.05 was considered statistically significant.

RESULTS AND DISCUSSION

Table 1. Demographic and Nutritional Status of Participants

Variable	Malnourished (n=128)	Well-nourished (n=172)	p value
Age (years, mean ± SD)	27.4 ± 4.8	28.1 ± 5.2	0.18
BMI (kg/m^2, mean ± SD)	17.8 ± 1.2	24.6 ± 2.8	<0.001
Serum albumin (g/dL, mean ± SD)	3.1 ± 0.4	4.2 ± 0.3	<0.001
Iron deficiency (%)	74 (57.8)	58 (33.7)	<0.001

The table shows that malnourished mothers had significantly lower BMI and serum albumin levels, with a higher prevalence of iron deficiency, indicating a poorer nutritional profile compared with well-nourished mothers.

Table 2. Endocrine Parameters in Malnourished vs. Well-nourished Mothers

Parameter	Malnourished	Well-nourished	p value
TSH (mIU/L, mean ± SD)	3.8 ± 0.9	2.4 ± 0.7	<0.001
FT4 (ng/dL, mean ± SD)	0.8 ± 0.2	1.2 ± 0.3	<0.001
Fasting insulin (µIU/mL, mean ± SD)	8.5 ± 2.1	12.3 ± 3.4	<0.001
Cortisol (µg/dL, mean ± SD)	22.1 ± 5.4	16.8 ± 4.7	<0.001

Malnourished mothers demonstrated significant endocrine imbalance, with elevated TSH and cortisol alongside reduced FT4 and fasting insulin levels, reflecting disrupted hormonal homeostasis.

Table 3. Antenatal Complications and Neonatal Respiratory Morbidity

Outcome	Malnourished (n=128)	Well-nourished (n=172)	p value
Gestational hypertension (%)	38 (29.7)	26 (15.1)	0.003
Preterm labor (%)	32 (25.0)	24 (14.0)	0.02
Gestational diabetes (%)	18 (14.1)	34 (19.8)	0.18
Neonatal respiratory morbidity (%)	46 (35.9)	28 (16.3)	<0.001
Neonatal ICU stay >48h (%)	40 (31.3)	22 (12.8)	<0.001

Malnourished mothers experienced a significantly higher incidence of gestational hypertension, preterm labor, and neonatal respiratory morbidity, with longer neonatal ICU stays.

This study reveals substantial associations between maternal malnutrition, endocrine imbalance, antenatal complications, and neonatal respiratory morbidity. Malnourished mothers manifested significant disruptions in key hormonal regulators, including elevated TSH and cortisol levels and reduced FT4 and insulin concentrations. These findings underscore the physiological stress and metabolic perturbations associated with inadequate nutrition during pregnancy. The observed endocrine alterations are consistent with the concept that nutritional deficits impair thyroid hormone synthesis, modulate hypothalamic-pituitary-adrenal axis activation, and influence insulin sensitivity, collectively affecting maternal homeostasis.[13-14]

The increased prevalence of antenatal complications among malnourished women aligns with the altered endocrine milieu. Gestational hypertension and preterm labor were significantly more common in the malnourished cohort, suggesting that inadequate nutrition may compromise vascular adaptation and uteroplacental function. These phenomena likely reflect a combination of impaired metabolic reserves and heightened inflammatory responses, which have been implicated in the pathogenesis of hypertensive disorders and preterm birth. The non-significant difference in gestational diabetes prevalence may indicate a complex relationship influenced by multiple factors beyond nutritional status alone.[15-17]

Neonatal respiratory morbidity was markedly higher among infants born to malnourished mothers. This association persisted despite adjustment for gestational age and birth weight, suggesting that maternal nutritional status exerts a direct influence on fetal lung development and neonatal respiratory adaptation. Nutrient deficiencies, particularly in proteins, vitamins, and trace elements, may impede surfactant production and alveolar maturation, rendering neonates more susceptible to respiratory distress. The extended neonatal ICU stays further reflect the clinical burden associated with compromised respiratory outcomes.[18-20]

The interplay between maternal endocrine imbalance and neonatal outcomes highlights a biologically plausible pathway linking nutrition to fetal development. Elevated maternal cortisol may cross the placental barrier, influence fetal hypothalamic-pituitary-adrenal axis programming and predisposing the neonate to respiratory dysfunction. Similarly, thyroid hormone insufficiency can compromise fetal organogenesis, including pulmonary maturation, reinforcing the need for early detection and management of endocrine perturbations in malnourished pregnancies.

These findings hold significant clinical and public health implications. Maternal nutrition emerges not only as a determinant of maternal health but as a critical factor in shaping the endocrine environment and subsequent neonatal adaptation. Integrating nutritional screening and supplementation into routine antenatal care could mitigate the observed adverse outcomes. Moreover, endocrine evaluations may serve as valuable adjuncts in identifying women at elevated risk for complications, enabling proactive management strategies.

While this study provides comprehensive insights, certain limitations warrant consideration. The cross-sectional design limits causal inference, and the reliance on hospital-based sampling may influence the generalizability of results. Nonetheless, the robust statistical associations and alignment with biologically plausible mechanisms strengthen the relevance of the findings within similar clinical settings.

CONCLUSION

Maternal malnutrition significantly disrupts endocrine balance and is associated with increased antenatal complications and neonatal respiratory morbidity. These findings underscore the critical need for integrated nutritional and endocrine assessments in antenatal care to improve maternal and neonatal outcomes and address a key gap in perinatal health management.

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